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Target Acquisition With Color Versus Black and White Television

by

Dan W. Wagner
Aircraft Systems Department

OCTOBER 1975

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R. G. Freeman, III, RAdm., USN . . . . Commander

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FOREWORD

This experiment on target acquisition with color and black and white television systems was conducted at the Naval Weapons Center, China Lake, Calif., between January and June 1975. The task is part of a Naval Air Systems Command program on imaging system specifications and display quality. It is supported by AirTask No. A3400000/008B/5F55-525-402 under the direction of LCDR Paul Chatelier (AIR-340F).

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(U) *Target Acquisition With Color Versus Black and White Television*, by Dan W. Wagner. China Lake, Calif., Naval Weapons Center, October 1975. 26 pp. (NWC TP 5800, publication UNCLASSIFIED.)

(U) Two simulator experiments, differing only in field of view (FOV), were conducted to investigate air-to-ground target acquisition with color and black and white television. A television camera obliquely viewed a terrain model from a simulated altitude of 4,000 feet with two FOVs: 4.5 and 3.25 degrees. Subjects searched for green, olive, brown, and earth-colored tanks and trucks as the camera "flew" over the terrain. It was found that (1) color TV was not generally superior to black and white TV; (2) the earth-colored targets provided more correct detections at faster response times than the other colors; (3) tanks were detected, but not identified, slightly faster than trucks; (4) target detection and identification was affected by the background; and (5) the smaller FOV more than doubled correct target detections (41 versus 86%).

CONTENTS

INTRODUCTION

Color television has been commercially available since the mid 1950s but only in the last few years has a concerted effort been made to use this technology for airborne applications. While considerable literature exists on the effectiveness of black and white television for a variety of applications, very little comparable information is available for color TV. Recent literature reviews concerned specifically with the relative effectiveness of color coding as compared to achromatic coding have found insufficient data available concerning its effects on performance of realistic tasks.[1,2]

The present study was designed to compare target detection and identification performance on color television with that on black and white television using realistic imagery. Previous studies of this type include one by Fowler and Jones who evaluated the differences in acquisition performance with color and black and white display presentations of ground targets.[3] The targets were building silhouettes of various colors placed on a terrain model in areas of similar and dissimilar target-to-background colors. Their results indicate that while some target-to-background combinations were detected at greater ranges on color compared to black and white TV, overall there was no significant difference between the two viewing modes.

Another such study investigating target detection performance with color and with black and white TV also varied target color, background color, resolution, and contrast while controlling background clutter.[4] The targets were green, brown, and gray model tanks viewed against a green or brown terrain model background under three resolution and contrast conditions. It was found that color TV provided more detections than black and white TV (particularly for the gray targets) and, under the controlled conditions, background was not a significant factor, although it figured prominently in several interactions.

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[1] New Mexico State University, Dept. of Psychology. *Color Research for Visual Displays*, by R. E. Christ and W. H. Teichner. Las Cruces, New Mexico, NMSU, LC, July 1973. P. 54. (JANAIR Report 730703, publication UNCLASSIFIED.)

[2] Hughes Aircraft Co., Aerospace Group. *Master Monitor Display Study*. Culver City, Calif., HAC-AG, November 1973. Pp. 4–11. (Report No. P73-464, publication UNCLASSIFIED.)

[3] Martin-Marietta Corp. *Target Acquisition Studies: (1) Transition from Direct to TV Mediated Viewing; (2) Target Acquisition Performance: Color vs Monochrome TV Displays*, by F. D. Fowler and D. B. Jones. Orlando, Fla., MMC, January 1972. (Report OR 11,678, publication UNCLASSIFIED.)

[4] Naval Weapons Center. *Target Detection with Color Versus Black and White Television*, by Dan W. Wagner. China Lake, Calif., NWC, April 1975. (NWC TP 5731, publication UNCLASSIFIED.)

In addition to the variables of viewing mode (color versus black and white), target color, and target background, two other variables of interest are target type and field of view (FOV). When tank, truck, and truck-trailer targets were used by Sorenson in a detection and identification experiment involving flare light, he found that trucks were significantly more often detected and identified than the other two types of vehicles.[5] It would be useful to determine if Sorenson's findings may be generalizable to other conditions. It would also be useful to determine the extent performance is affected by a change in FOV.

The objective of these experiments was to determine the effect of the following variables on target detection and identification performance on television:

1. Viewing mode: color versus black and white.
2. Target color: green, olive, earth, and brown.
3. Targets: tanks and trucks.
4. Target area: eight various backgrounds.
5. FOV: 4.5 and 3.25 degree.

Maintained as constants were:

1. Altitude: 4,000 feet (simulated).
2. Camera depression angle: 30 degrees.
3. Velocity: 82 miles per hour (simulated).

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[5] Aerospace Medical Research Laboratory. *The Effect of Flare Drift on Target Acquisition Performance*, by Russell A. Sorsenson. Wright-Patterson AFB, Ohio, AMRL, October 1974. (AMRL-TR-74-73, publication UNCLASSIFIED.)

METHODOLOGY

The two experiments described in this report used a closed-circuit color/black and white television system and a terrain model to investigate the effects of color and black and white television on target detection and identification performance. Except for the television camera lenses, the two experiments employed the same apparatus.

APPARATUS

The equipment used to measure visual detection and identification performance is listed below. Figure 1 provides a sketch of the test layout.

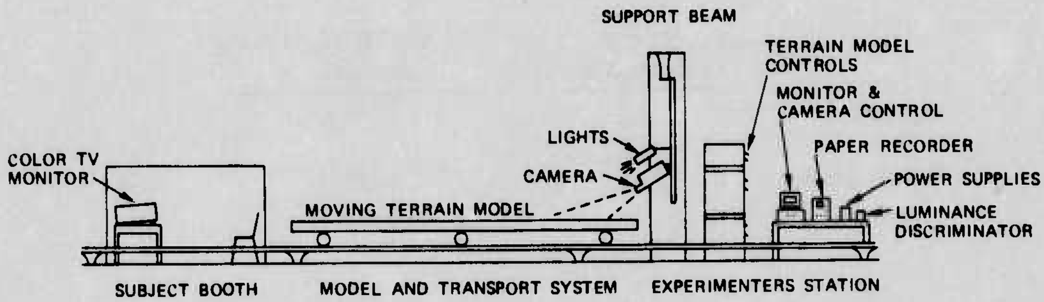

FIGURE 1. Sketch of Experimental Layout.

Terrain Model

The terrain model is an 8- by 20-foot three-dimensional, 1000:1 scale model simulating an area 1.8 miles wide by 4.5 miles long. It contains numerous trees and shrubs that can be relocated as desired and varies in color from light to dark greens and browns. The entire model moves on rails, with the speed control mounted in an adjacent console. The test track prepared for the experiments simulated an area 0.25 mile wide by 3 miles long. The track consisted of rolling hills up to 300 feet in height, with heavy ground cover approximately 3 feet in depth. Trees, shrubs, rocks, wood clutter, and small buildings were arranged along the track so that in appearance, the terrain resembled moderately foliated foothills.

After the test track was prepared, eight target areas were selected that provided: (1) an unobstructed target-to-camera line of sight, (2) comparable elevation to minimize fluctuations in angular subtense, and (3) a clear area of about 1 inch (100 feet simulated) around the targets. Two small, flat tacks the length and width of the targets and painted to blend with the background were inserted into each target area to provide ground-level platforms for consistent target placement and orientation. Target area luminance measurements are included in the target/target area contrast matrix in the Appendix.

Targets

Four pairs of tanks and four pairs of trucks of 1000:1 scale were used as targets for both experiments. All targets were of the same maximum dimensions in height, width, and length. Each target pair was painted one of four colors, with a pair of tanks color-matched with a pair of trucks. The four target colors were flats of green, light olive, dark earth (a reddish brown), and brown (comparable respectively to Munsell 7.5 GY 4/4, 10 Y 4/4, 10 R 3/2, and 10 YR 4/4). Tanks and trucks provided nearly the same target-to-background luminance contrast values when averaged across the eight target areas. Additional details on target color, size, and contrast are in the Appendix. The targets were placed on the terrain model in pairs, about one vehicle-length apart, as if moving along in a convoy. They were seen broadside (perpendicular to the line of sight) and oriented left to right. Tanks and trucks were not mixed. Never more than one target pair at a time was in the displayed scene. The targets subtended the following visual angles to the subjects on the TV monitor:

	Vertical, minutes of arc	Horizontal (target pair), minutes of arc
Experiment A	16.6	75.6
Experiment B	21.5	98

Color Television Camera

A Cohu Model 1230D color television camera was suspended on a boom over the terrain model. A Cohu Model 1290 camera control unit was attached by cable to the camera and located at the experimenter's station. The horizontal limiting resolution of 335 television lines (luminance) was measured with an oscilloscope and Retma chart using an average 20-millivolt peak-to-peak signal as limiting criteria. The camera color setup procedure, as modified for this experiment, and pertinent camera specifications can be found in the Appendix.

Telephotometer

A Gamma Scientific Model IC 2000K telephotometer was used to measure target-to-background contrast values, chromaticity, and also luminance settings for display color balance. Additionally, the instrument was used to measure target and background chromaticity coordinates directly on the terrain model. These values are contained in the Appendix.

Optical Comparator

A Hellige IRT Mark 3 color comparator was used to color balance the observer's display. The comparator provided a color temperature standard for setting the red, green, and blue background and gain controls to illuminant D (6500°K) as specified by both the TV manufacturer and SMPTE Practice RP 371969.[6] The display background controls were adjusted to 1.0 footlambert while the gain controls were adjusted to 20.0 footlamberts display luminance.

Paper Recorder

A Sanborn No. 322 two-channel recorder was used to record both the time each target was in view and the subject's response. A time marker on the right-hand margin provided 1-second time marks.

Luminance Discriminator

The recorder's "target-in-view" channel was activated by a luminance discriminator (a pulse coincidence detector designed and built at the Naval Weapons Center) connected between the camera control unit and recorder. The device was calibrated to be sensitive to 0.4-inch white cardboard squares placed opposite each target but out of the displayed scene. The display width was over-scanned 0.5 inch to provide this capability.

General Equipment

A Tektronix 7613 oscilloscope with a synchronization separator and standard Retma resolution chart were used to measure the resolution.

A Visual Information Institute No. 216 test pattern generator and No. 306 signal source synchronization generator were used to check initial gray-scale rendition, size, linearity, and focus adjustments as well as to generate the window signal required for color balance adjustments.

Target Area Lighting

Lighting was provided by two Berkey-Colortron Model 100-412 lights with 6-inch sweep focus Fresnel lenses and light diffusers mounted above the camera. The lights contained 1000-watt, 3200° bulbs that in the test configuration, provided 750 footcandles illumination to the target area.

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[6] CONRAC, Inc. *Installation and Operating Instructions. Video Monitor Model 5000/12 Series.* San Diego, Calif. Manual 1B-106212-999A, 1974.

Subject's Booth

The subject's booth contained the display, a chair, an adjustable forehead restraint that maintained viewing distance at 50 inches, and the subject's response button. The response button was wired to the paper recorder and power supplies. Black curtains were attached to the booth to prevent glare and control ambient illumination. Ambient illumination measured at the display was less than 2 footcandles.

Camera Lenses

Camera lenses for the two experiments were as follows:

Experiment	Lens	f-stop	Field of view (height), deg	Displayed vertical dimension (simulated), feet
A	5-to-1 zoom	5.8	4.5	1231
B	6 inch	5.8	3.25	881

EXPERIMENTAL DESIGN

Color TV was compared to black and white TV to assess the effects on detection/identification performance of the following variables: two types of targets, four target colors, and eight background areas. A nested 2 x (2 x 4 x 8) factorial design was used in which 10 subjects saw the experimental conditions in color and 10 more subjects saw them in black and white for a total of 64 observations per subject, 640 observations per independent group, and 1,280 observations in all.[7] The experimental design is shown in Figure 2. Each subject saw 16 test runs with four pairs of targets presented on every run. Presentation order was randomized for all the factors except target area which was counterbalanced. The experimental design was identical for both Experiment A and B.

SUBJECTS

Subjects for the two studies were 40 (20 subjects for each experiment) male and female employees of the Naval Weapons Center between the ages of 22 and 47. Fourteen of the subjects had participated previously in target acquisition studies. The selection criteria for the subjects was 20/20 or better near and far visual acuity as tested on the Bausch and Lomb Armed Forces Vision Tester. Additionally, those subjects who participated in the color viewing mode had normal color vision as determined with the Dvorine Pseudo-Isochromatic Plates.

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[7] Keppel, Geoffrey. *Design and Analysis: A Researchers Handbook.* Englewood Cliffs, N. J., Prentice-Hall, Inc., 1973.

VIEWING MODE \ TARGETS / COLOR / AREA		TANKS				TRUCKS			
	COLOR	GREEN	OLIVE	EARTH	BROWN	GREEN	OLIVE	EARTH	BROWN
	AREA / Ss	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8
COLOR	S1								
	S2								
	S3								
	S4								
	S5								
	S6								
	S7								
	S8								
	S9								
	S10								
BLACK & WHITE	S11								
	S12								
	S13								
	S14								
	S15								
	S16								
	S17								
	S18								
	S19								
	S20								

FIGURE 2. Experimental Design for Bo'h Experiments.

PROCEDURE

Each subject was allowed to directly view the terrain model and two sets of practice targets (one pair of tanks and one pair of trucks), then was brought into the test booth and given recorded instructions (see the Appendix). The subject then made four practice runs containing a total of 20 pairs of targets. At the "Ready" signal, the subject placed his forehead against the restraint bar and the paper tape recorder was activated. At the "Begin" signal the terrain model was switched on and the subject began searching the scene for a target pair. The task of detecting a target entailed differentiating vehicles from the other clutter objects (trees). Identification entailed distinguishing the type of vehicles: tanks or trucks. When a target was detected, the subject pressed the hand-held response button, recording a spike on the recorder paper. When he identified it, he pushed the button again and verbally responded "Tank" or "Truck." At the end of a test run, a gray-scale bar pattern was generated on the subject's display and the subject was requested to "Relax." The experimenter then returned the terrain model to the starting position and arranged the targets for the next run. A target presentation lasted 10 seconds in Experiment A and 6.6 seconds for Experiment B. There was an interval of from 12 to 16 seconds between the appearance of the targets, and about 1 minute between test runs. The experiments required about 1 hour per subject.

ANALYSIS

Three measures were used to assess the effects of the experimental variables: percent targets correctly detected, target detection time (or latency), and target identification time. Target detection and identification time was defined as the time between the target entering the scene and the subject's response. Missed and incorrectly identified targets were scored as 11 seconds and 8 seconds for Experiments A and B respectively.

Analysis of variance was used to determine the significance of the latency data. When a main effect with more than two levels was found to affect detection performance significantly, Newman-Keul's post hoc comparison tests were made to determine significant differences of the levels of that parameter.[7] Error scores were tabulated but, due to the nature of the individual differences, the data were not analyzed. Descriptions of the types of errors and the number of each type committed for both experiments are contained in the Appendix.

RESULTS

The results of these experiments indicate, first, that for the range of target colors used, color TV does not offer a generally significant performance improvement over black and white television. Second, target color affects target acquisition performance, with one target color (dark earth) providing more detections at faster response times than the other target colors (flat green, olive, and brown). Third, tanks were slightly easier to detect (but not identify) than trucks. Fourth, the target's area or background affects the ease with which a target can be detected and identified. And, fifth, use of a 3.25-degree FOV markedly improves target acquisition performance over a 4.5-degree FOV for both color and black and white television. Figures 3 and 4 illustrate these findings.

The analysis of variance summary of Experiments A and B is shown in Table 1. The table shows that target area, target color, and the target color by viewing mode interaction were significant in both experiments for all measures.

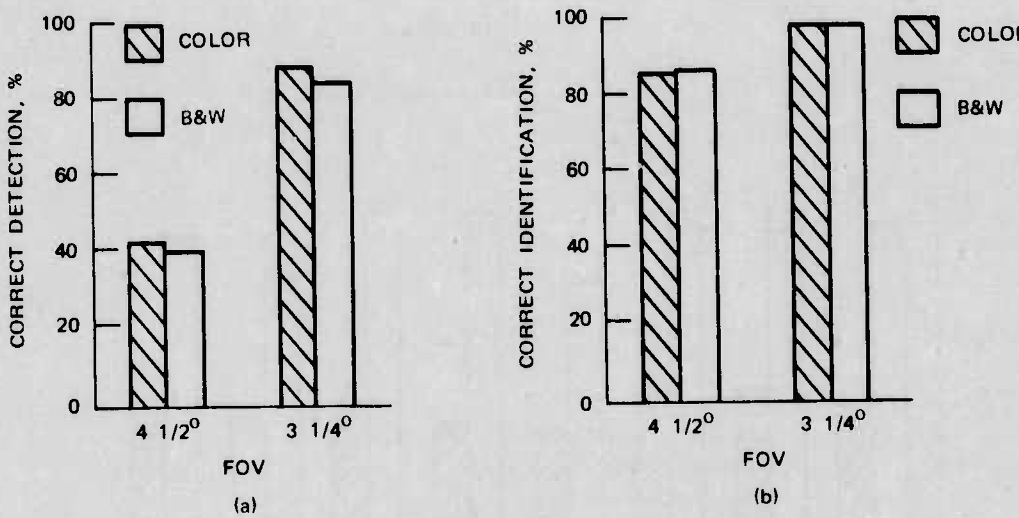

FIGURE 3. Percent (a) Correct Detections and (b) Identifications Given Correct Detection, as a Function of Field of View for Color and Black and White Television.

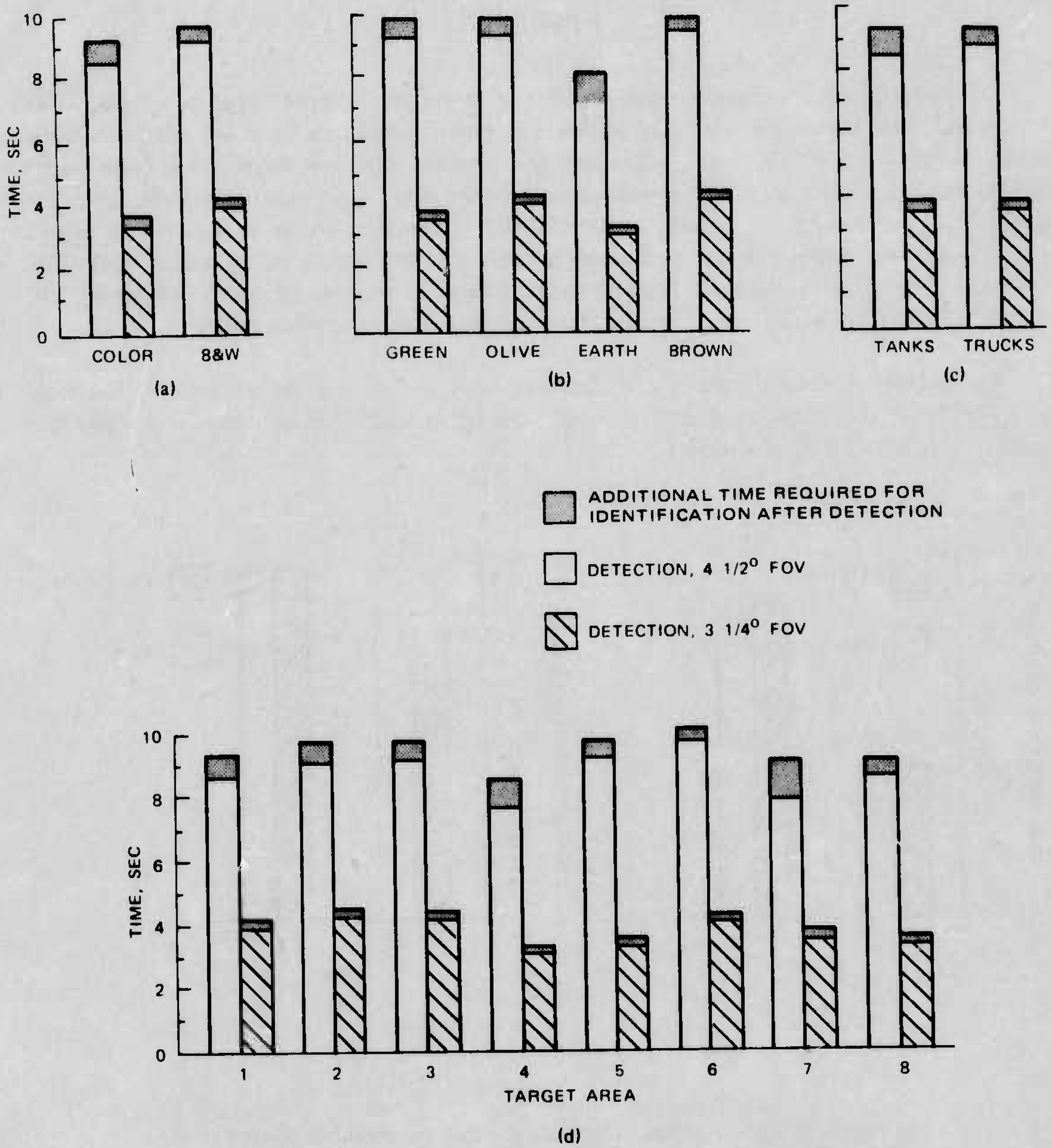

FIGURE 4. Mean Response Time as a Function of (a) Viewing Mode, (b) Target Color, (c) Targets, and (d) Target Area for 4.5- and 3.25 deg FOV Detection and Identification Performance.

TABLE 1. Experiments A and B; Analysis of Variance Summary of Percent Targets Detected and Response Times to Target Detection and Identification as a Function of Target Area (A), Target Color (C), Target Type (T), and Viewing Mode (M).

Source	d_f	Percent detections		Time to detection		Time to identification	
		Experiments					
		A	B	A	B	A	B
A	7	**	**	**	**	**	**
C	3	**	**	**	**	**	**
T	1	—	—	*	—	—	—
M	1	—	—	—	—	—	—
CM	3	**	**	**	**	**	**
AC	21	**	—	**	—	*	—
AT	7	—	**	—	**	—	**
CT	3	—	—	—	—	—	—
AM	7	—	—	—	**	*	—
TM	1	*	—	*	*	*	—
ACT	21	—	—	—	**	—	—
ACM	21	—	*	*	*	—	—
ATM	7	—	—	—	—	—	—
CTM	3	—	—	—	—	—	—
ACTM	21	*	*	—	—	**	**

* $p < .05$
** $p < 0.1$

Significant two-factor interactions are illustrated in Figures 5 and 6. Differences within levels of the primary variables were evaluated with Newman-Keul's post hoc comparison tests for the response time data.

The comparison tests indicated that the earth target color was significantly different from the green, olive, and brown target colors, but that these last three target colors were not significantly different from each other. The comparison tests also indicated a number of differences in target areas. Table 2 shows these differences for Experiment B with area 4 different from 1, 2, 3 and 6, and area 2 different from 4, 5, 7, and 8, along with other significant differences noted in the table. Comparison tests were also done on the two-factor interactions of target color by viewing mode (CM) and targets by viewing mode (TM). The mean detection time of the earth targets seen in color and the brown targets seen in black and white were significantly different from each other and all the remaining combinations. The differences between the targets seen in color and those seen in black and white were significant.

TABLE 2. Experiment B Significance Between Target Areas for Detection Response Time.

Target area	Target area 4	5	8	7	1	6	3	2
4	...				**	**	**	**
5		...				**	**	**
8			...				**	**
7				...				**
1					...			

**p < .01

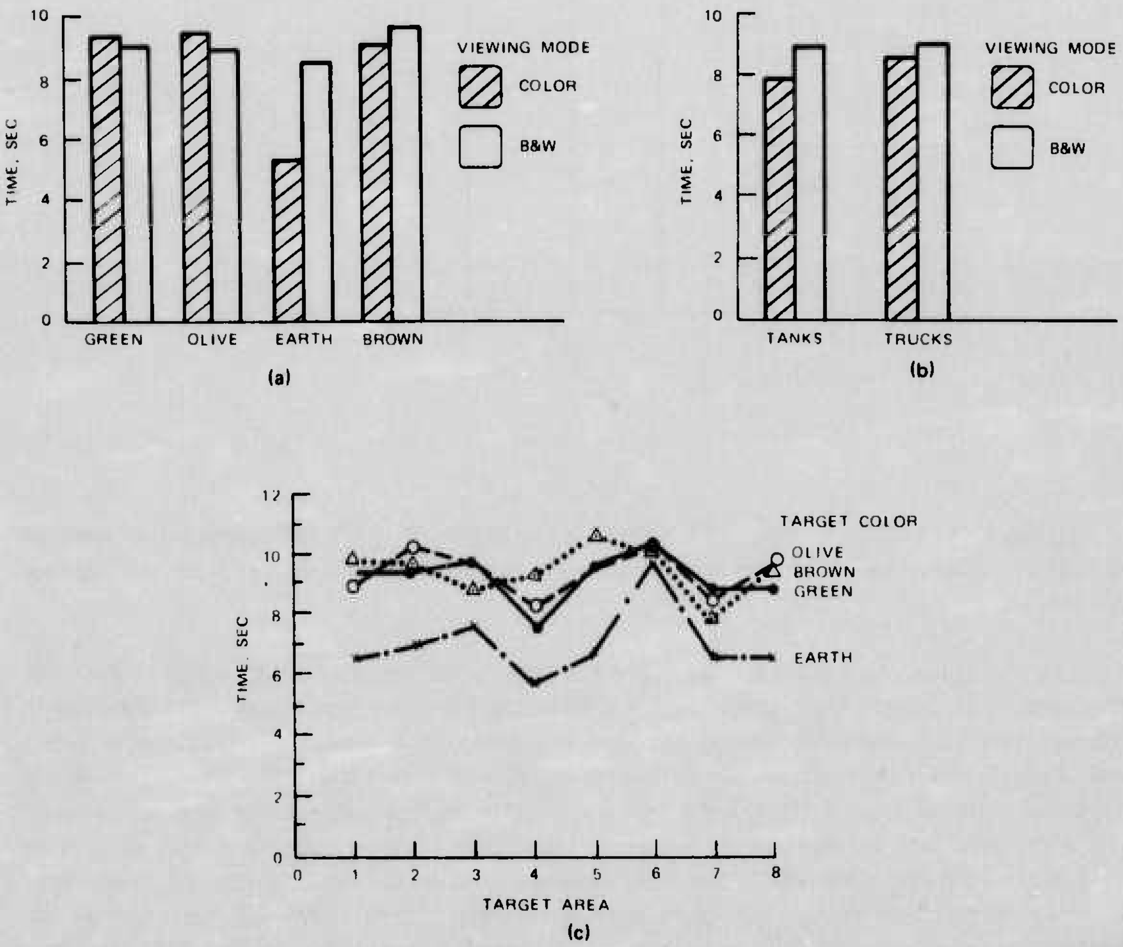

FIGURE 5. Experiment A Mean Target Detection Response Time as a Function of Significant Two-Factor Interactions: (a) Viewing Mode by Target Color, (b) Viewing Mode by Targets, and (c) Target Area by Target Color.

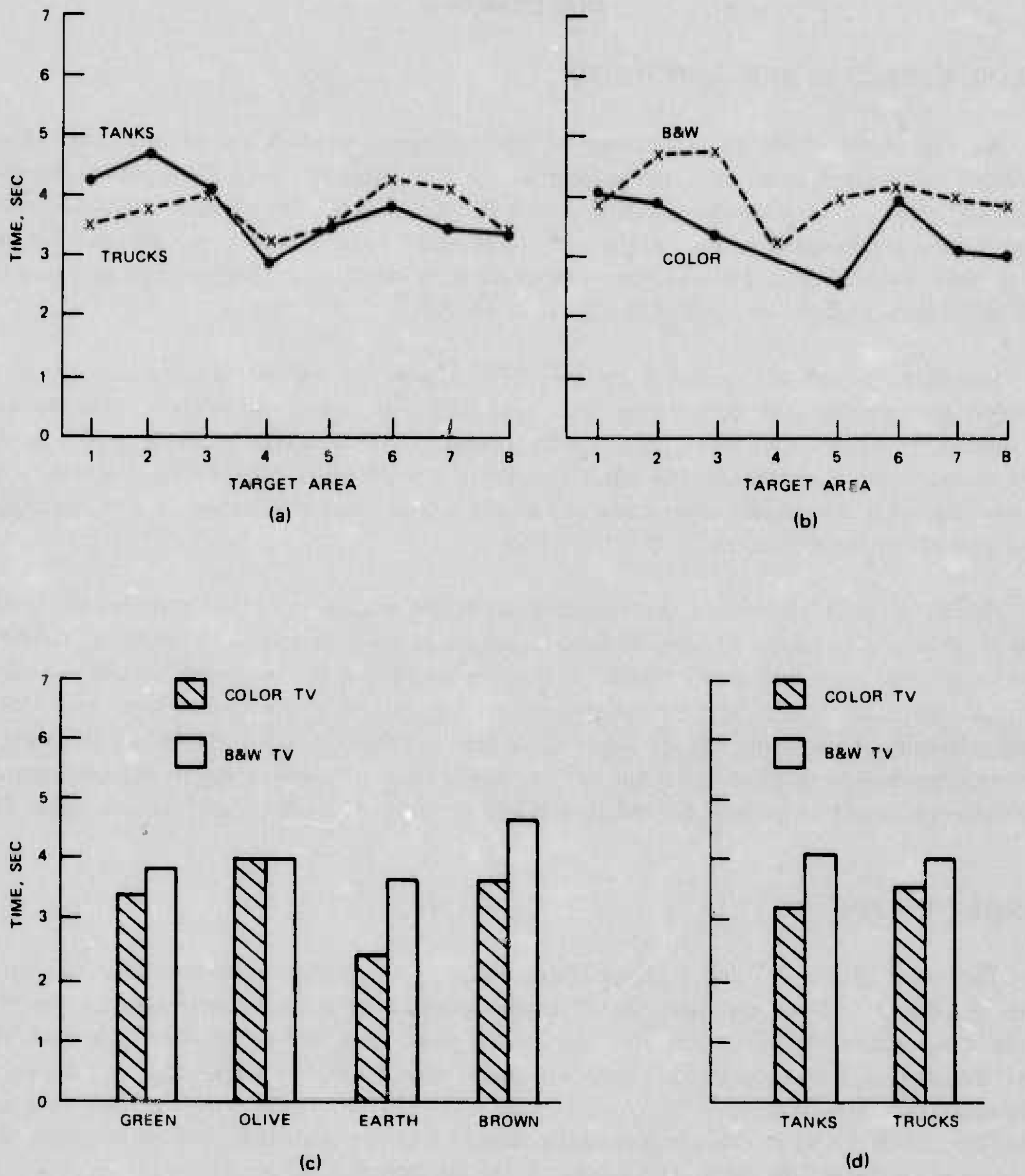

FIGURE 6. Experiment B Detection Response Time Two-Factor Interaction: (a) Target Area by Targets, (b) Target Area by Viewing Mode, (c) Target Color by Viewing Mode, and (d) Targets by Viewing Mode.

DISCUSSION

COLOR VERSUS BLACK AND WHITE

Analysis of the effects on performance of color compared to black and white TV showed no significant difference in either detection or identification time. Although color TV appears to improve performance by 2.2 to 4.3% (Experiments A and B respectively) when summed across the other variables, this improvement is attributable solely to the earth-colored targets seen on color TV and not to color TV in general. The significant viewing mode by target color (CM) interactions found for both experiments support this point (see Figures 5a and 6c).

Identification was not improved by color TV. Figures 4a and 4b show a comparison of detection and identification performance with color and with black and white TV for the two experiments. It can be seen that while color TV appears to aid detection performance, due to the earth-colored targets contribution, this effect completely disappears for identification performance. In other words, while a particular target color may greatly enhance correct detection, it does not appear to increase correct identifications.

Results of prior research in the applied experimental setting are mixed with respect to the benefits of presenting targets in color. In three investigations, color in some way helped the task[4,8,9] while in another, color was of no benefit.[3] It is worth noting that in the present research and those just cited, color did not generally decrease performance but, in certain situations, helped performance. If color imaging devices using realistic colors for a target acquisition task can ever be produced and maintained as cheaply as black and white devices, then there is evidence to suggest that performance with color TV would be at least as good as, and in some instances better than, black and white TV.

TARGET COLOR

The effect of target color on target detection and identification performance was shown in Figure 4a. Figure 7 shows that earth-colored targets presented on color TV were detected over 90% of the time compared to 50 to 60% detections for the green, olive, and brown targets. On black and white TV, there was little difference among the target colors (shades of gray) except that brown, in Experiment B, was more difficult to detect. This difficulty with the brown targets seen on black and white TV can be traced to the contrast matrix contained in the Appendix. The matrix shows that brown targets averaged only about 11% contrast across the various target areas.

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[8] Aerospace Medical Research Laboratory. *SEEKVAL Project 1A1: Effects of Color and Brightness Contrast On Target Acquisition*, by R. L. Hilgendorf and John Milenski. Wright-Patterson AFB, Ohio, AMRL. July 1974. (AMRL-TR-74-55, report UNCLASSIFIED.)

[9] Wong, K. W., and N. G. Yacoumelos. "Identification of Cartographic Symbols from TV Displays," HUM FACTORS, Vol. 15, No. 1, 1973.

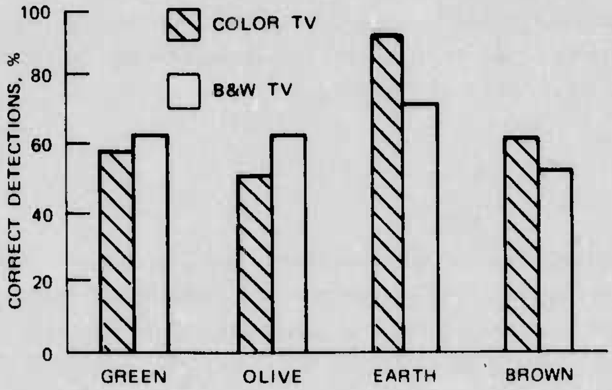

FIGURE 7. Percent Targets Detected with Color and Black and White TV as a Function of Target Color. (Data combined from Experiments A and B.)

Target color was a significant variable in the present experiments and in the previous study in this series.[4] For the three experiments in this series, five different shades of green, four shades of brown, three shades of gray, and a dark earth have been used as target colors. Other objects in the display such as trees and scrubs have been various greens, browns, and tans, so that there is a greater proportion of like colors for the green and brown targets than for the earth and gray targets. In a review of the literature on this topic, Christ and Teichner state that, "The data show a definite trend for a decreasing advantage of color coding as the proportion of non-targets which have the same color as targets increased."[1]

TARGETS

The analysis of the effect of type of target on detection and identification time showed that, compared to trucks, tanks were slightly easier to detect (but not identify) in Experiment A. The viewing mode by target interaction for this experiment shown in Figure 5b indicates that targets, particularly tanks, were easier to detect in color than in black and white. There was no significant difference between tanks and trucks for Experiment B although interactions of targets with target area and viewing mode are seen in Figures 6a and 6d.

The physical appearance of the tank's smooth curves would seemingly make them more difficult to detect than the truck's sharp angled lines against a foliage background. However, on closer inspection, the tanks appeared to reflect some glint from the lights whereas the trucks did not. Also, the tanks had cannon barrels while the trucks had no comparable feature. These features, particularly the glint, may have been marginally helpful for tank detection with the 4.50-deg FOV, although why it should be more pronounced in color than black and white TV is not understood. For the 3.25-deg FOV it is reasoned that the gross physical differences between targets and terrain were sufficient to allow accurate detection.

The findings do not support Sorenson's results[5] that trucks are easier to detect and identify. It may be that under flare light trucks are easier to see and under the lighting conditions of the present experiments tanks have an advantage. It would seem reasonable for the present to assume that results are not generalizable over a variety of conditions.

TARGET AREA

The effect of target area on target detection and identification performance was shown in Figure 4d. The analysis indicated that target detection and identification performance varied with target area. Target area was also involved in significant interactions with target color (Figure 5c), targets (Figure 6a), and viewing mode (Figure 6b). Generally, areas 4, 5, 7, and 8 provided faster response times than areas 1, 2, 3, and 6.

These target area performance differences can be partially explained by the contrast matrix in the Appendix. Areas 4, 5, and 8 provide the highest, and areas 1, 2, and 3 the lowest target-to-background luminance contrast values. However, areas 6 and 7 are just opposite of what would be expected with the lower average contrast area 7 providing better performance than the higher contrast area 6. Inspection of the target areas revealed no obvious reason for this discrepancy. As noted elsewhere,[4] the findings from a number of studies on background or target area effects are inconsistent with it being significant in some studies and not significant in others. The findings from the present experiments support the contention that background effects can significantly influence performance and should not be ignored in target acquisition studies.

FIELD OF VIEW

The two experiments contained in this report were identical except Experiment A had a 4.5-deg FOV and Experiment B a 3.25-deg FOV. Experiment B provided more correct detections (86 versus 41%) and identifications (99 versus 87%) with faster mean detection response times (3.7 versus 8.7 seconds) and mean identification response times (0.2 versus 0.7 second) than Experiment A. Figure 3 illustrated the percent targets correctly detected and, given correct detection, the percent targets correctly identified as a function of Experiments A and B, separated according to the contributions of color and black and white TV.

Although the procedure and methodology for the two experiments were the same, the change to a smaller field of view for the second experiment produced some changes in the televised scene. The major change is the magnification of the scene. For example, the targets on the screen were enlarged from 3/16 inch for Experiment A to 5/16 inch for Experiment B. Since the viewing distance remained constant for both experiments, this meant an increase in angular subtense from 16.6 to 21.5 minutes of arc to the subjects. Magnification affects background also in that a smaller area of the terrain is displayed. This has the effect of reducing the amount of displayed foliage (clutter) while increasing the apparent distance between clutter objects or target and clutter. Another effect of magnification is the change in speed and available search time for objects moving down the display. For example, in the present experiments where camera lens-to-target velocity remained

constant, targets were in view for 10 seconds for the 4.5-deg FOV but only 6.6 seconds for the 3.25-deg FOV. It appears from the data that the loss in search time is relatively unimportant considering the performance improvements derived from the magnified scene. Figure 8 shows the cumulative probability of correct target detection for the two fields of view plotted as a function of time. The figure indicates, for example, that at 5 seconds the probability of detection was only .21 for the 4.5-deg FOV but .84 for the 3.25-deg FOV. It can be seen that the smaller field of view rather dramatically aids performance.

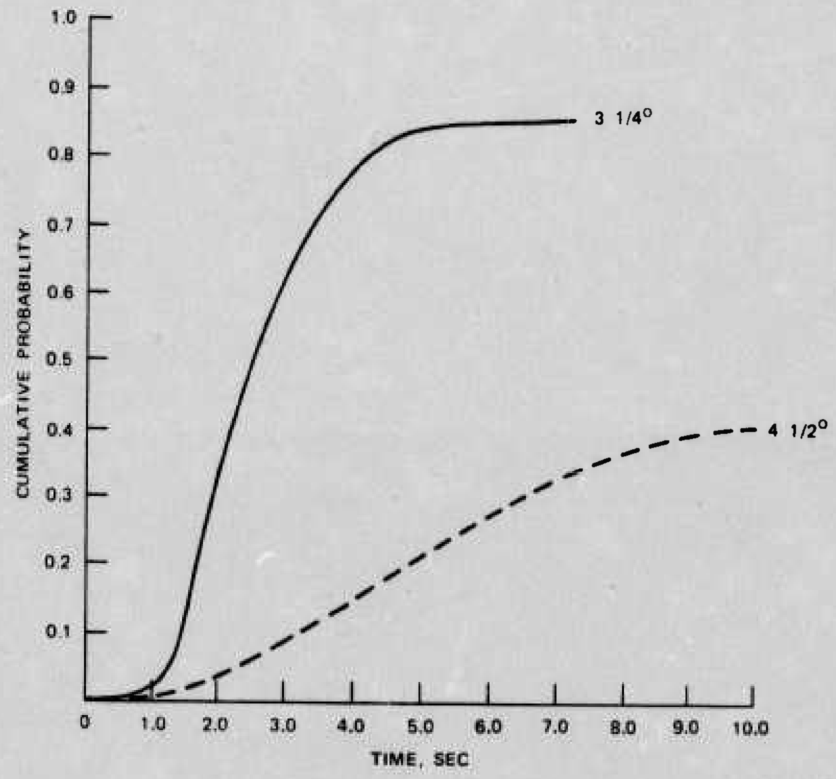

FIGURE 8. Cumulative Probability of Correct Target Detection as a Function of Time for 3.25- and 4.5-deg Field of View.

Appendix
EXPERIMENT DETAILS

TARGETS

Size: 8 mm long x 4 mm high x 3 mm wide

Paint Colors: Flat Green, Pactra XF5

Flat Light Olive, Pactra XF 54

Flat Dark Earth, Pactra M-20 (6 parts) mixed with Flat White Pactra F2 (1 part)

Testors Flat Brown 116.6 (8 parts) mixed with Pactra Flat Black XF-1 (1 part)

Chromaticity Coordinates:

	Green	Olive	Earth	Brown
X	.429	.469	.482	.496
Y	.475	.456	.400	.427

Target Area Chromaticity Coordinates:

X	.462 to .466
Y	.463 to .471

TABLE 3. Target by Target Area by Viewing Mode Luminance Contrast Matrix.

TARGET AREA

		1 COLOR (20.2)	1 B&W (18.2)	2 (19.5)	2 (17.8)	3 (16.6)	3 (14.8)	4 (24.9)	4 (22.1)	5 (23.6)	5 (21.0)	6 (21.1)	6 (19.1)	7 (17.7)	7 (15.7)	8 (21.6)	8 (19.5)	COLOR |X̄|	B&W |X̄|	TGT COLOR |X̄|	TOTAL* TGT COLOR |X̄|	TGT |X̄|
TANKS	GREEN COLOR (18.2)	−10		−7		10		−27		−23		−14		3		−16		13.8		14.2	15.2	
	GREEN B&W (16.0)		−12		−10		8		−26		−24		−16		2		−18		14.8			
	OLIVE (20.5)	1		5		23		−18		−13		−3		16		−5		10.5		10.5	12.2	14.6
	OLIVE (18.2)		<1		2		23		−18		−13		−5		16		−7		10.6			
	EARTH (16.3)	−19		−16		−2		−35		−31		−23		−8		−25		19.9		20.7	18.9	
	EARTH (14.3)		−21		−20		−3		−35		−32		−25		−9		−27		21.5			
	BROWN (19.7)	−2		1		19		−21		−17		−7		11		−9		10.9		10.8	10.7	
	BROWN (17.8)		−2		<1		20		−19		−15		−7		13		−9		10.8			
TRUCKS	GREEN (17.5)	−13		−10		5		−30		−26		−17		−1		−19		15.1		16.0	15.2	
	GREEN (15.3)		−16		−14		3		−31		−27		−20		−3		−22		17			
	OLIVE (18.3)	−9		−6		10		−27		−22		−13		3		−16		13.3		13.8	12.2	14.4
	OLIVE (16.2)		−11		−9		9		−27		−23		−15		3		−17		14.3			
	EARTH (17.0)	−16		−13		2		−32		−28		−19		−4		−21		16.9		17.0	18.9	
	EARTH (15.3)		−16		−14		3		−31		−27		−20		−3		−22		17			
	BROWN (20.3)	<1		4		22		−18		−14		4		15		−6		10.5		10.6	10.7	
	BROWN (18.2)		<1		2		23		−18		−13		5		16		−7		10.6			
COLOR TV |X̄|		8.9		7.8		11.6		26.0		21.8		12.5		7.6	8.1	14.6						
B&W TV |X̄|			10		9		11.5		25.9		21.8		14.1		8.1		16.1					
AREA |X̄|		9.5		8.4		11.5		26		21.8		13.3		7.9		15.4						

*TOTAL AVERAGE OF BOTH TARGETS.

NOTE: NUMBERS IN BOXES ARE TARGET–TO–BACKGROUND LUMINANCE CONTRAST VALUES IN PERCENT, DETERMINED BY AVERAGING 6 MINUTES OF ARC PHOTOMETER APERTURE ON SIX SPOTS OF THE TARGETS AND TEN SPOTS ON THE TARGET AREA IMMEDIATELY ADJACENT TO THE TARGETS USING THE FORMULA $\frac{L_t - L_b}{L_b} \times 100$. THE NUMBER IN THE UPPER LEFT HAND CORNER OF EACH BOX IS FOR COLOR TV WHILE THE NUMBER IN THE LOWER RIGHT HAND CORNER IS FOR B&W TV. THE MEANS ACROSS THE BOTTOM AND AT THE FAR RIGHT ARE WITHOUT REGARD FOR SIGN. THE NUMBERS IN PARENTHESES ARE LUMINANCE VALUES IN FOOTLAMBERTS.

CAMERA SETUP

The camera was set up according to factory procedures* except the following:

Camera aimed at black and white card with black about 30% of picture.
Beam control to 77 (meter) . . . . .adjust for eveness of white.
Beam control to 80 (meter) . . . . .adjust for eveness of white.
Auto Sens to 80 (meter) . . . . adjust for eveness of black and white.

NOTE: The auto iris and auto target were turned off for the experiments and final Sens adjustment was made using terrain model, not meter.

* Detailed specifications and procedures can be found in Cohu Technical Manual 6X-609(A), Cohu, Inc., Box 623, San Diego, California.

MONITOR SETUP PROCEDURES

Follow factory setup procedure except following:

Red, green, and blue background pots . . . . .Adjust to optical comparator low brightness white at 1.0 footlambert
Red, green, and blue gain pots . . . . .Adjust to optical comparator high brightness (6500°K) white at 20.0 footlamberts
BRT control . . . . .Reduce to 1.0 footlambert
Background controls . . . . .Increase to 20.0 footlamberts
Gain controls .Adjust to filter 1 white

ERRORS

Three types of errors occurred: (1) false detections (FD), subjects responded when no target was in view; (2) false identifications (FID), subjects correctly detected targets but incorrectly identified them; and (3) false detection and identification (FDID), subjects detected and identified targets that were not present.

SS	Experiment A			Experiment B		
	FD	FID	FDID	FD	FID	FDID
1	–	4	1	–	–	–
2	–	–	–	–	–	–
3	3	2	17	2	–	3
4	–	5	2	3	–	–
5	–	–	–	–	–	–
6	2	1	4	–	1	1
7	1	3	2	–	–	14
8	–	–	–	–	–	–
9	–	–	–	–	1	–
10	5	2	1	–	–	–
11	2	2	2	–	1	–
12	2	3	–	–	6	–
13	–	4	5	–	2	1
14	–	2	2	–	1	–
15	–	–	1	–	–	–
16	1	3	1	–	–	–
17	2	2	2	–	–	–
18	–	1	1	–	1	–
19	–	4	17	–	–	–
20	–	–	1	–	2	–
Totals	18	38	59 = 135	5	14	19 = 38

SUBJECTS' RECORDED INSTRUCTIONS

"You are participating in an experiment designed to assess an observer's target detection and identification performance on television. Your task during this experiment will be to detect and identify several tank and truck targets like the ones you just saw on the T-M. This is what they look like on TV. Targets will always be shown in pairs—a pair of trucks or a pair of tanks. There will never be two sets of targets in view on the screen at the same time. The instant you see a pair of targets, push this button and release it. This is target detection. If you then decide for example that the target is a tank, push the button again and say 'Tank'. This is target identification. Do not guess wildly but neither do you have to be absolutely positive. Just be fairly sure. If you are unsure whether the targets are tanks or trucks, do not push the button again. If you detect and identify a target at the same instant, push the button and say 'Tank' or 'Truck' Always call out the sector 1, 2, or 3 as the target goes off the monitor. Also, it may happen that you have indicated a target and then change your mind and decide that what you saw was not a target. If this should occur, simply call out 'Error', and then continue with the task.

"There will be four practice runs and then 16 data gathering runs. When I say 'Ready', place your forehead against this bar. Be prepared to respond when I say 'Begin'. The experiment will last about 1 hour. Remember, when you detect a target, push the button. Then if you can identify it, push the button again, and say 'Truck' or 'Tank'. Always call out the sector as the target goes off the monitor. If you detect and identify the target at the same instant, push the button, name the target and then the sector. And if you respond to a false target, just say 'Error'. Are there any questions?"

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